Experimental Trauma Surgery
Medical Faculty
Justus-Liebig University of Giessen (Germany)

2018 Proceedings of the International Conference on Trauma Surgery Technology in Giessen

Topic:
Patient centred Technology Design in Traumatology

16 to 18 November 2018
Funded by the Deutsche Forschungsgemeinschaft

University Medical Faculty
Giessen (Germany)

Dear Colleagues

It has been our pleasure to host you from 16 to 18 Nov this year at Giessen for the 1st International Conference on Trauma Surgery Technology.

This gathering of experts has been made possible by the generous financial support of the Deutsche Forschungsgemeinschaft (ref No BO 4961/4-1). Christopher and Wolfram commenced their doctoral studies within the Engineering Department at the University of Cambridge, and continued to pursue aligned research across Europe in Germany, Italy, Croatia, and throughout the United Kingdom. Anonymous DFG-reviewers deemed the work of sufficient merit to award funding to set up the 1st International Conference on Trauma Surgery Technology in Giessen. Accordingly, we therefore acknowledged the generous support of the DFG and raised a toast to the reviewers' health during the dinner on day one of the symposium.

From left to right, Chris, Anna, and Wolfram on 08 Sept 2018 during the preparatory workshop at Wolfson College, Cambridge (UK).

The overarching goal of the gathering was to define a concept for technology design research in Giessen to improve patient outcomes through the design of assistive technology that assists both patients and surgeons. The emerging field of regenerative rehabilitation where trauma patients are treated by methods of regenerative medicine promises great improvements for our field, but clinical success is yet to be realised. The symposium was specifically organised to acknowledge and address these issues.

We have started preparations for the 2019 conference which will focus on the possibilities offered by additive manufacturing for treatment concepts in our field. Information will be send to the participants and will be posted under the following link on the 2019 homepage: https://www.uni-giessen.de/fbz/fb11/institute/klinik/chirurgie/uch/forschung/trauma-surgery-technology-conference-2019/

Welcome to Giessen!

Your scientific committee

Conference Organisation

WA Bosbach, Giessen

S Drahorad, Giessen

M Hofacker, Giessen

KE Bosbach, Freiburg

M Ebeling, Giessen

Scientific Committee and Editors of the Proceedings

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Applicants WA Bosbach and C Wilkinson

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Programme overview

Friday, 16 Nov 2018

- Arrival, hotel check-in, get-together

Saturday, 17 Nov 2018

- Day 1 – registration, presentations

Sunday, 18 Nov 2018

- Day 2 - interactive morning session
- Departure, Frankfurt International Airport (FRA) will be reached by train by 3.57 pm

2018 conference homepage: patient centred technology design in traumatology

https://www.uni-giessen.de/fbz/fb11/institute/klinik/chirurgie/uch/forschung/trauma-surgery-technology

2019 conference homepage: additive manufacturing in traumatology

https://www.uni-giessen.de/fbz/fb11/institute/klinik/chirurgie/uch/forschung/trauma-surgery-technology-conference-2019/

Conference venue: Giessen University Medical Faculty

29, Klinikstrasse
Giessen 35390
Germany

Hotel: Hotel Alt Giessen

30-32, Westanlage
Giessen 35390
Germany

Restaurant: Brewery Alt Giessen

30-32, Westanlage
Giessen 35390
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Press review – 2018 Conference in the News

12 Nov 2018 "*Ameliot co-hosts the 2018 International Conference on Trauma Surgery Technology*"
https://ameliot.com/giessen-conference-2018/

18 Oct 2018 "*Trauma Rehabilitation Symposium on state of the art patient-centred technology design*"
http://www.eng.cam.ac.uk/news/trauma-rehabilitation-symposium-state-art-patient-centred-technology-design

18 Sept 2018 "*Cambridge alumni win funding award to host expert symposium*"
https://www.cambridgenetwork.co.uk/news/cambridge-alumni-funding-for-expert-symposium/

Designing surface features for improved bio-interface characteristics

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Abstract

Cell and bacteria activities are highly mediated by the mechanical characteristics of their substrate material including roughness and morphology, grain structure, and its stiffness. In our line of research, we have considered severe plastic deformation techniques, known as efficient metal-forming and grain refining processes, to provide the treated metallic materials with novel mechanical properties by modifying nanoscale surface characteristics, possibly affecting interactions with the biological environment. The in vitro studies evaluated the capability of severe shot peening, to modulate the interactions of nanocrystallized metallic biomaterials with cells and bacteria. The treated 316L stainless steel, biodegradable Mg alloys, and pure Fe surfaces were investigated regarding surface topography, grain size, hardness, wettability and residual stresses, as well as their interaction with cells and bacteria.

Introduction

The mechano-responsive behaviour of cells and bacteria motivated these series of studies. Mechanical surface treatments were applied to enhance the biofunctionality of biocompatible metals. In the particular case of biodegradable metals, the possibility of controlling the corrosion rate could be an additional effect of the surface treatment. The application of biodegradable magnesium-based materials in the biomedical field is highly restricted by their low fatigue strength and high corrosion rate in biological environments. For pure iron, on the other hand, the significantly low degradation rate caused by formation of passive iron oxide and hydroxide layers at physiological environment has highly restricted their application. Herein, besides 316L, we treated the surface of a biocompatible magnesium alloy AZ31 and also pure iron by severe shot peening to evaluate the potential of surface grain refinement to enhance this alloy's functionality in a biological environment.

Method and materials

AZ31 samples were studied regarding micro/nanostructural, mechanical, chemical characteristics and cytocompatibility properties. The evolution of surface grain structure, surface roughness, wettability, and chemical composition, as well as in depth-microhardness and residual stress distribution, fatigue behaviour and corrosion resistance were investigated. Cytocompatibility tests

with osteoblasts were performed. The same set of experiments were performed on pure Fe and 316 samples. For the latter, the effects of the induced surface modifications were studied regarding cell morphology, adhesion, and proliferation of primary human osteoblasts as well as the adhesion of multiple bacteria strains.

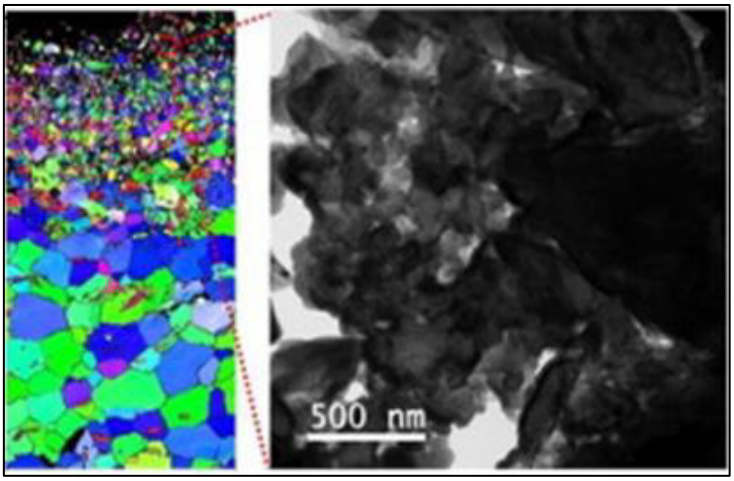

Figure 1: Microscopy observation of gradient nano structure starting from the surface (AZ31)

Results and discussion

The results revealed that severe shot peening can significantly enhance mechanical properties of all treated materials without causing adverse effects on the growth of surrounding osteoblasts. The corrosion behavior of AZ31 was not improved; nevertheless, removing the rough surface layer with a high density of crystallographic lattice defects provided a good potential for improving corrosion characteristics. In case of pure Fe, the results evidenced the high potential of improved mechanical characteristics and accelerated degradation rate particularly at higher exposure times [1].

The results on 316L indicated a significant enhancement in surface work hardening and compressive residual stresses, maintenance of osteoblast adhesion and proliferation as well as a remarkable decrease in the adhesion and growth of gram-positive bacteria (S. aureus and S. epidermidis) compared to non-treated samples. Impressively, the decrease in bacteria adhesion and growth was achieved without the use of antibiotics, for which bacteria can develop a resistance towards anyway. The expression of vinculin focal adhesions from osteoblasts was found to be singularly and inversely related to grain size, whereas the attachment of gram-positive bacteria decreased with increasing nanoscale surface roughness and was not affected by grain refinement [2].

Conclusions and future work

These studies demonstrated the advantages of the proposed surface treatment to produce multifunctional materials for improved implant functions.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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Trauma in the Elderly: Clinical and Rehabilitative Perspectives

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Introduction

Due to the rise in healthcare standards and improved practice over the last decades, there is an associated increase in the life expectancy of patient populations. As a result, elderly patients present a more prevalent patient cohort that is particularly susceptible to certain disease processes, among which accidents and traumatic injuries are of significance across many aspects of care. Rehabilitation comprises an integral part of the treatment process in such events.

Method and materials

Rehabilitation can take place across different settings. A multimodal approach addressing all areas of dysfunctionalities and morbidities is essential.

Discussion and conclusion

The implementation of targeted rehabilitation programs tailored to the individual patient has been associated with improved outcomes. Emphasis on establishing further rehabilitation units and continued optimisation of present facilities would certainly aid in providing more comprehensive treatment to such an important patient cliental.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Designing for Users – from Products to Systems

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Introduction

There is no doubt that today we have all changed the way to interact with the different products and services to which we have access; the way we experience them has become as important as their final purpose.

We make decisions based on others opinion, (and others experience), we seek to compare points of view before we get a new product or even before we book a hotel for our vacation. We are living in a time where users are empowered more than ever and we need to design our work for, with, and around them.

Method and materials

As we design for users the most important thing is to empathize - to be in the users shoes, and to have a human understanding [1]. In the case of a patient healthcare, it is even more important. We can all relate to being in hospital, and it needn't require huge effort to improve if not transform the patient experience and aid recovery.

Co-creation: It is necessary to work with patients and know their feeling, fears, and emotions, and to know their pain points during the trauma experience [2]. This feedback is crucial in the development of assistive technologies. It is therefore important that we understand our users and speak the same language to ensure the journey from injury to recovery is well understood, managed and improved.

Design system: In visual design, to 'create a design system' means that a product consists of a whole universe made up of different small pieces, each connected to another, following a common path, and sharing the same language [3]. This must be open, transparent and clear for the whole team.

Results and discussion

Designing from personal experience often overlooks what is obvious to actual users, and misses the opportunity to empower users [4]. A product team usually thinks they know the design problem, design space, and their users but they will be surprised with the results derived by working collaboratively with real users.

Conclusions and future work

Consideration of the usability and the user experience of assistive technologies, will clearly translate into positive user feedback, increased acceptance and adoption, and increases the potential for success. Regardless of the commercial implications, this approach ultimately benefits the end product and produces better products for all users of assistive technology [5].

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Porous structures for biomedical applications by combining electrospinning and phase separation processes

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The development of advanced systems for the efficient treatment of skin wounds is becoming crucial in order to face global demographic issues (ageing population, obesity, and diabetes). An ideal biomedical device for wound care should promote the complete regeneration of the injured tissue, effectively restore its biological activity and aesthetic aspects, while reducing inflammation and preventing microbial invasion by bacteria. The risk of infection is one of the main concerns in wound care, where the colonisation of the wound site by bacteria can negatively affect the healing process and delay it.

Here we present the development of bioactive dressings that encapsulate natural active agents with antibacterial activity. The composite scaffolds were produced by combining biopolymers and medicinal plant extracts. The scaffolds produced have high potential in the wound healing field, because, together with antibacterial activity, their porosity is suitable for gas permeation, and their mechanical properties can be engineered. Furthermore, their mechanical flexibility allows conformability to the wound site, providing protection of the injured tissue against external mechanical and thermal stresses. For our future work, it is planned to investigate the mechanical interaction between scaffolds and on-growing cells by the finite element method.

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Design Strategies for Improved Patient Outcomes

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Introduction

The acceptance and seamless regular use of medical devices by end-users is a complex process, demanding the alignment of four layers of contextual factors: (1) characteristics of the healthcare environment in which the device is used; (2) knowledge and supplies required for the efficient operation of the device; (3) expectations about the performance and possible results reached with the device; and (4) demands placed by the device on the organisational structure of the healthcare delivery system [1]. Medical devices have long been subjected to safety evaluations (ISO 14971), as well as clinical effectiveness and related cost-efficiency assessments [2]. However, human factors' assessments (ISO 62366) addressing patients' and clinicians' usability issues in medical device design are a relatively new area, which is currently increasing in importance due to changing regulations. Generally, human behaviour is affected by three sets of factors: (1) personal (i.e. self-esteem, personality traits, locus of control, emotions, health concern); (2) demographic (i.e. age, gender, race, ethnicity, education, income, religion); and (3) environmental (i.e. diagnosis, stress, media exposure) [3].

Method and materials

A user study considering these three human behaviour factors was conducted with 40 end users, both patients and clinicians, to create a system for helping them manage their lives with Chronic Obstructive Pulmonary Disease (COPD) in the UK and Germany. User insight was gained through contextual and observational research with a disease monitoring device embedded in patients' homes and clinicians' offices, as well as quantitative tracking of data and real-time use by patients and their healthcare teams over the period of four months.

Results and discussion

This twinned co-design co-research with a prototype embedded in users' naturalistic usage environments from early stages of design allowed to gather and address intended users' lifestyle needs, usage motivation, underlying feelings that the illness and the device bring about, and di-verse levels of technological competence. In relation to clinicians, this process also enabled the design

team to gather and address important workload management needs and in particular the coping with technology-induced instantaneous information, re-minders and warning signals, as well as the relationships between co-clinicians and the individuals they cared for. In addition, it allowed to investigate how better patient condition visibility would increase rapidity of responses and the transmission of information between healthcare resources and departments, and changes in care provision.

Conclusions and future work

This work demonstrates the value of applying the contextual user research approach during medical device design, driving all research activities through early embedding of a medical system prototype in natural user environments to generate continuous design embodiment of the identified needs for constant user evaluation.

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Histomorphometric analysis of trabecular mineralisation in osteoporotic sheep

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Introduction

In the older age the bone gets weaker. That's the reason why in an aging society the number of patients with osteoporosis and osteoporotic fractures increase immense. The treatment of these fractures are a major challenge right now and in the future because there is a high number of implant failure. We need suitable and well known animal models of osteoporosis to develop new and specific bone implants.

The FDA recommends to generate small and large animal models to study new osteoporosis treatments[1]. In case of the large animal models the sheep is convenient because the bone size and morphology is similar to the human ones, the hormone cycle is comparable to the human ones, they have a calm and friendly behavior, have low living costs and are easy to get in a bigger number [2]. In the last decades a few groups of scientists searched for the best sheep model of osteoporosis. Especially Lill et al. 2002 [3] published the first pilot study with radiological analyses and Zarrinkalam et al. 2009 [4] added for the first time histomorphometric results to the radiological findings. In our model we wanted to compare the different described treatments with an detailed radiological, histological, serological and mechanical analysis. In this study my focus was to analyze in histological samples the trabecular microstructure and mineralization. In this context we established a macro to automate the time consuming bone histomorphometry in the open-source software ImageJ [5].

Method and materials

We investigated 31 female merino land sheep over a period of 8 months divided in four groups: control, ovariectomy, ovariectomy with dietary limitation (Calcium and Vitamin D), and ovariectomy with dietary limitation and steroid injection as described in El Khassawna et al. 2017 [6]. Samples

were collected of the iliac crest, the lumbar spine and the distal femur. Harvested bone biopsies were analysed by light and fluorescence microscopy.

The established macro was recently published [5]. It uses the image processing software ImageJ and the plugins Trainable Weka Segmentation and BoneJ. It can be used to measure parameters like trabecular thickness, mineralized, non-mineralized bone area, etc.

Future work

We are looking forward to publishing our results, comparisons with other animal models of osteoporosis and discussions in the context of the current scientific knowledge.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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Clinical aspects and therapy of peri-implantitis

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Introduction

No clinical guidelines exist for implant related infections. Due to a lack of evidence, therapy is mainly based on experience. In 2013, the first Consensus meeting on peri-prosthetic joint infection was organized to discuss therapy concepts and future perspectives on implant related infections in Philadelphia, USA.

Method and Materials

Based on current literature available at PubMed and clinical case examples, the authors give an overview of clinical aspects, therapy principles and future perspectives of peri-implantitis.

Figure 1: Radical debridement is necessary to achieve treatment success in revision arthroplasty

Results and discussion

Diagnosis of implant related infections is challenging. Besides history, clinical evaluation and imaging, histopathological, and microbiological examination build the cornerstone of diagnostics. Adequate treatment is based on the differentiation of acute and chronic infections. Instead of the formerly time-related distinction, biofilm formation on implants or sequesters is crucial for the clinical differentiation between acute and chronic. While implant retention is a sound treatment option in acute implant related infection, treatment of chronic infections regularly needs implant removal. The time-point for reimplantation depends on patient health, identification of infection causing microbes, and local soft tissue status. Infect eradication has to be achieved by radical surgical debridement as well as local and systemic antibiotic treatment. Reimplantation of orthopaedic devices often results in larger implants due to bone defects. In chronic peri-implantitis, prosthesis reimplantation is commonly only possible after several weeks of treatment, many revision surgeries, and often not at all.

Conclusions and future work

Implant related infections are major threat for patients after joint replacement and osteosynthesis. Improvements of orthopaedic implants and bone substitutes are necessary to reduce the high burden imposed on the affected patients.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Biomechanical damage behaviour in cells under vibration

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A new method for exposing cells to mechanical vibration is presented. The method is based on the forced vibration response of a structure with living biological cells attached. For this, a new concept of bioreactor is introduced. This bioreactor is based on a vibrating disc instrumented with a piezoelectric patch (PZT). The PZT is used to excite the disk at its natural frequencies producing resonance to the structure and therefore amplifying considerably the vibration amplitude. Moreover, the structure can be excited out of resonance conditions to compare the results. Test group and control group of vibrating Osteosarcoma cells will be first implemented, having higher vibration amplitudes in the test group. Cell proliferation, the cell metabolic activity and extracellular matrix composition will be evaluated after the vibration experiment. Fields of application for the intended research are antibacterial measures, tumour therapies, and more.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Applying User Centred Design in Healthcare Settings

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Despite the rapid progress of digital health technologies in recent years, one of the main difficulties is in-depth communication and interaction with patients, nurses and doctors throughout the complex trauma and healthcare process [1]. Product designers in industry are typically constrained in terms of time and budget that frequently prevent them from consulting with end users while assessing the ease of use of the products they create [2]. Arguably this is even more acute for clinical engineers trying to deliver services to increasing numbers of patients with fewer resources. Rather than historically being considered an ill-afforded and expensive luxury [3], involving users within the design process can improve the applicability, acceptability, and adoption of the finalised product [4]. In so doing, it can reduce development risk [5], and add value in terms of improved design output. This approach enhances the overall experience of product interaction for the user and increases the viability and commercial success of the technologies developed [6].

Participatory and User Centred Design aims to develop technologies with the close involvement of all stake-holders and end-users throughout cycles of requirements gathering, prototype development, implementation, and evaluation [7]. It is important to capture user information at every stage of the design process and empower users by allowing them to influence the subsequent development. Participatory Design is viewed as an approach to better understand the true capabilities, prior experiences, needs, and desires of users in any given situation; factors that are imperative in creating more appropriate, usable, and useful products [8]. Participatory design is a belief that all people have something to offer at every stage of the design process, and that they can be articulate, creative, and inspirational, in generating new ideas and developing current thinking [9].

We seek to develop an approach based on the participatory or user centred design model [10] but developed to include representation of all care team members, with the patient remaining the primary focus. Indeed, a key focus of this workshop will be to discuss how such an approach can ensure that the needs and desires of the patient are used to drive the development of an appropriate care and rehabilitation package – including the care system and its administrators, nurses, doctors, technicians, assistive technology developers and providers.

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Conflict of interest

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Detailed programme

Friday, 16 Nov 2018

Arrival at Hotel Alt Giessen

Get-together at Brewery Alt Giessen

Day 1 - Saturday, 17 Nov 2018

08:00 am Breakfast at Hotel Alt Giessen

From 09:00 am Registration

09:30 am Introductory session, Chair WA Bosbach

WA Bosbach: *Workshop structure*

M Rupp: *Modern Trauma Surgery*

C Wilkinson: *Applying User Centred Design in Healthcare Settings*

11:00 am Coffee break

11:20 am Session 1 - Engineering design in medicine, Chair C Wilkinson

Engineering science talks:

A Mieczakowski: *Design Strategies for Improved Patient Outcomes*

M Menendez: *Interaction Design - from the System to the Individual*

D López: *Designing for Users - from Products to Systems*

Clinical application talks:

A Ismat, MD: *Trauma in the Elderly - Clinical and Rehabilitative Perspectives*

WA Bosbach: *Patient centred technology design for the treatment of calcaneus fracture*

01:00 pm Lunch break and group photo at Giessen University Medical Faculty

02:30 pm Session 2 - Mechanics and materials in medicine, Chair M Rupp and WA Bosbach

Engineering science talks:

Prof S Bagherifard: *Designing surface features for improved bio-interface characteristics*

E Mele*: Porous structures for biomedical applications:*
Electrospinning, phase separation, and 3D printing

D Valentin: *Biomechanical damage behaviour in cells under vibration*

03.45 pm Coffee break

Clinical application talks:

M Rupp, MD: *Clinical aspects and therapy of peri-implantitis*

M Mülke, MD: *Histomorphometric analysis of trabecular mineralisation in osteoporotic sheep*

07.00 pm Dinner at Brewery Alt Giessen

Day 2 - Sunday, 18 Nov 2018

08:00 am Breakfast at Hotel Alt Giessen

09:30 am Interactive workshop session, Chair A Mieczakowski

Key challenges in various medical technology areas and how design thinking can help to overcome them.

01:30 pm Departure from Giessen University Medical Faculty

Train departs from Giessen Train station at 02:54 pm

Arrives at Frankfurt International Airport at 03.57 pm

Source: www.bing.com/maps, date accessed 26 Sept 2018

List of participants

Participants from Germany:

Bosbach, Konstantin E, University of Freiburg

Dr Bosbach, Wolfram A, Justus-Liebig University of Giessen

Ebeling, Michèle, Justus-Liebig University of Giessen

Gocht, Florian, Justus-Liebig University of Giessen

Prof Heiss, MD, Christian, Justus-Liebig University of Giessen

Ismat, MD, Abdullah, Justus-Liebig University of Giessen

Mülke, MD, Matthias, Justus-Liebig University of Giessen

Roehr, Charline, Justus-Liebig University of Giessen

Rupp, MD, Markus, Justus-Liebig University of Giessen

Participants from the UK:

Dr Mele, Elisa, University of Loughborough

Dr Mieczakowski, Anna, University of Cambridge

Dr Wilkinson, Christopher, Director of Inclusign Ltd

Participants from Denmark:

Dr Menendez Blanco, Maria, University of Copenhagen

Participants from Italy:

Prof Bagherifard, Sara, Polytechnic University of Milan

Participants from Spain:

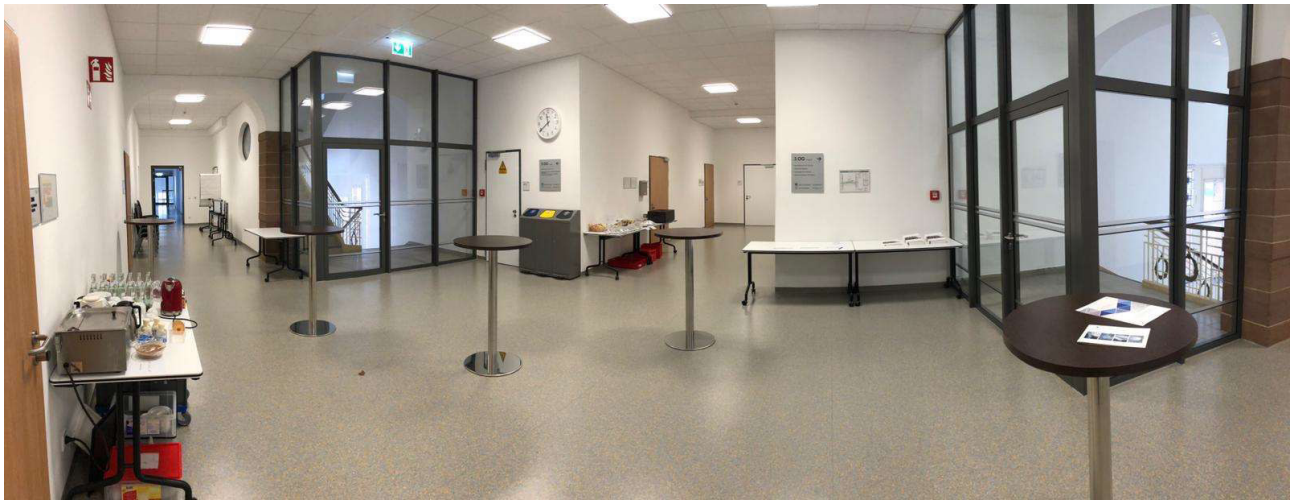
Ms López, Diana, Unidad Editorial

Dr Valentin, David, Universitat Politècnica de Catalunya

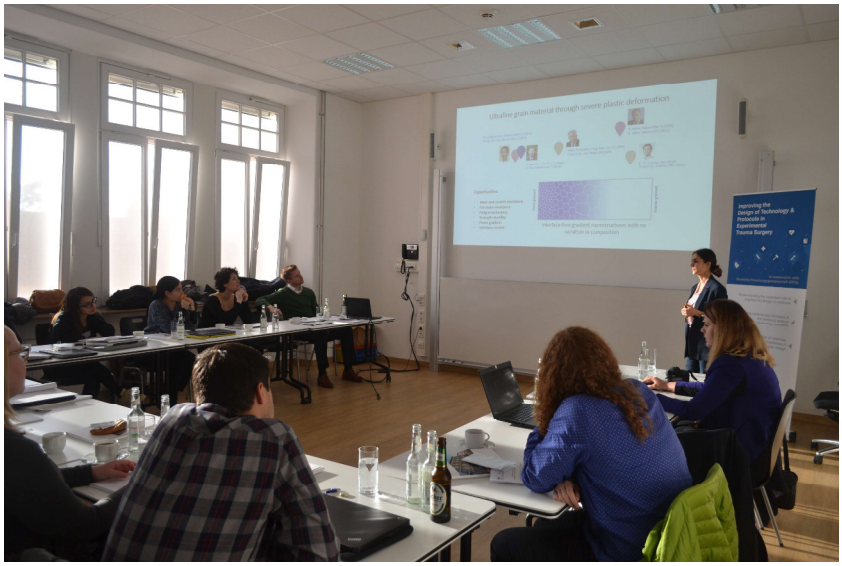
Impressions

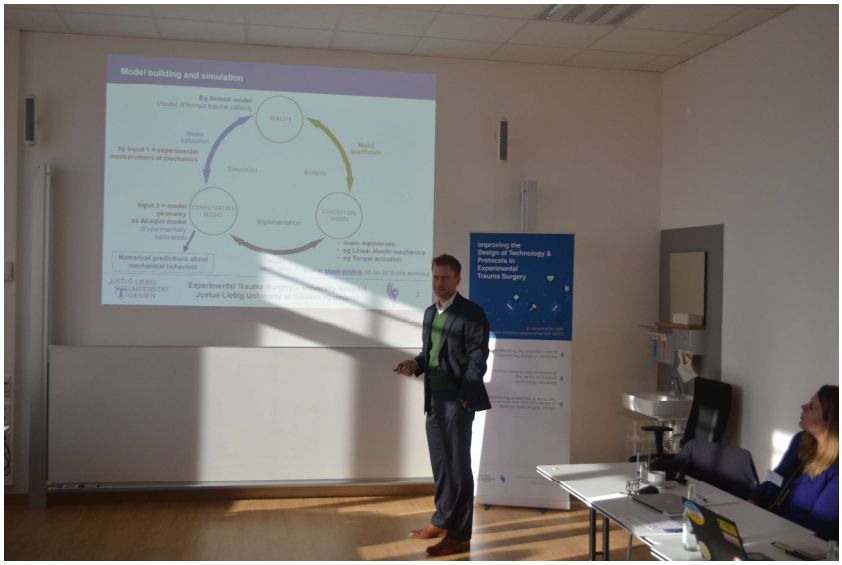
Group photo of the 2018 participants

Hall inside Giessen Medical Faculty on day 1



Presentations of day 1





Interactive session of day 2